First Draft

WSDOT Strategic Plan
Accelerated Bridge Construction (ABC)

Practice and Policy for ABC Bridge Projects

ABC Advisory committee

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Executive Summary

The Federal Highway Administration (FHWA) has been actively promoting the advantages of ABC. Proven benefits include minimized traffic disruption, improved work zone safety, and reduced on-site environmental impacts. Related traffic impacts derive from both expedited congestion relief projects and minimized traffic disruption due to reduced on-site highway construction activities.

Starting in 2008, WSDOT initiated a practice development and implementation for accelerated bridge construction (ABC). Under the direction of the State Bridge Engineer, WSDOT has established a task force that is headed by an ABC Advisory Committee to develop standards, guidelines, and key policies for implementing structure design for accelerated bridge construction.

Consisting of subject matter experts from Bridge Design Office, Bridge Construction, Regions, FHWA, Consultants, Research, Precast producers, Maintenance, Materials, and other relevant fields, the task force outlined a strategic plan to develop, implement, and promote ABC practice in Washington.

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Development of practice and policy for bridge projects

1.0 Introduction

The Federal Highway Administration (FHWA) has been actively promoting the advantages of ABC. Proven benefits include minimized traffic disruption, improved work zone safety, and reduced on-site environmental impacts. Related traffic impacts derive from both expedited congestion relief projects and minimized traffic disruption due to reduced on-site highway construction activities.

Safety enhancements benefiting the motoring public and highway workers, as well as lessened environmental impacts are directly attributable to limiting in-situ work requirements. For these reasons, European and Asian countries have already embraced the ABC philosophy for many of their urban construction projects.

Starting in 2008, WSDOT initiated a practice development and implementation for accelerated bridge construction (ABC). Under the direction of the State Bridge Engineer, WSDOT has established a task force that is headed by an ABC Advisory Committee to develop standards, guidelines, and key policies for implementing structure design for accelerated bridge construction.

Consisting of subject matter experts from Bridge Design Office, Bridge Construction, Regions, UCO, FHWA, Consultants, Research, Precast producers, Maintenance, Materials, and other relevant fields, the task force outlined a strategic plan to develop, implement, and promote ABC practice in Washington. The WSDOT ABC team has formulated strategy and work plans with the specific tasks outlined below. It is important, though, to understand that the success of ABC implementation rests largely on widespread acceptance of the associated techniques by project development staff (both internal and external), funding partners, and the contracting industry.

The goal of ABC is to deliver projects earlier to the traveling public: to effectively reduce the impacts of on-site construction to motorists. The Department's larger goal, as stated in its Mission/Vision statement, is to enhance mobility. Therefore, ABC should be viewed as a subset of a larger "accelerated project delivery" effort encompassing all aspects of project development through construction contract acceptance. Considerations related to lane rental rates should also be considered as part of this to address funding issues. This latter requirement stems from the fact that quite often new techniques involve unassigned risk that must be borne by the Contractor at a premium until the comfort level garnered from successes has been realized.

2. PRACTICE DEVELOPMENT

2.1 "Lessons" Learned Report and Survey

The first phase of the work plan is to document and evaluate ABC projects completed in the last 10 years. The survey will develop a database that identifies project goal, defines ABC techniques employed, and quantifies obstacles encountered in the projects. As "Lessons Learned", effectiveness of the mitigation strategies will be evaluated and a strategy will be formulated to improve future ABC projects.

The Advisory Committee will collect design and construction specifications used in other states and countries with moderate-to-high seismic hazards. Information on the performance of bridges with seismic ABC details during earthquakes or other extreme events will be evaluated. Workshops will be held with other states and national agencies sharing lessons learned from previous case studies and technical research results. The following lists the task items:

- Develop a "Lessons Learned" report on recent ABC projects in Washington State
  - Document ABC projects; evaluate obstacles, successes, and improvements for future projects.
  - Post the report on-line for public access.
  - Report to be "living" document, updated periodically.
- Collect design and construction specifications used in other states and countries with moderate-to-high seismic hazards.
- Collect information on the performance of bridges with seismic ABC details during earthquakes or other extreme events.
- Share accelerated construction practices from other national and international agencies.
- Publish case studies.
- Attend workshops and conferences sharing lessons learned in other states.
- Review details used by others including railroad, building, offshore and international industries.
  - "Guidelines for Accelerated Bridge Construction using Precast/Prestressed Concrete Components" by the PCI Northeast Bridge Technical Committee: http://www.pcine.org.
  - FHWA Precast Connections Details Manual

1.2 ABC Decision Criteria and Type Selection

2.2.1 Project and Traffic Impact Assessment

ABC reduces traffic delays and hazards, and provides infrastructure improvement at a fast pace. The results yield benefits to the traveling public and the regional economy. ABC does require special construction practice that typically demands a premium in construction costs. Since typically ABC project examples not as efficient as the conventional "day" shift construction, ABC project delivery costs could yield a 30-100% increase to the conventional construction costs.

ABC can result in substantial economic benefits that can offset most construction cost premiums. Conventional bridge construction typically induces traffic delays and congestion for an extended time period (average of 9 to 15 months). The induced traffic congestion adversely affects individual traveler's budgets and the region's economy; impacts air quality due to increased vehicle emissions, and reduces the quality of life due to personal time delays. Also, untimely service for workforce, supplier, and customers can incur significant costs to the traveling public and region businesses. In some instances, the associated costs to the public from traffic delays can reach into the tens of thousands of dollars per weekday. ABC can reduce traffic delays and hazards, and thus yield economic savings to the traveling public and the regional economy. While the State may pay a construction premium in advance, the cost savings from reductions in delays, fuel and travel time would apply directly to the traveling public.

To demonstrate the benefits of ABC, new evaluation measures/criteria are introduced to evaluate the structure type used in a specific project. First, a Bridge Construction Impact index is used to identify a structure type alternative (see attached).

- Facility Category
  - Residential community traffic
  - Local streets (business and residential).
  - State routes, major city arties, or minor utilities (water channel etc).
  - Interstate or State Highways
  - Essential artery, major landmark facilities, utilities, or natural hazard (waterways, swamp lands, etc.)

- Mission Impact Type -Capacity Improvement/Restoration-

I. Improve or restore capacity to relieve existing traffic congestion due to an event, incident, or growth demand.
  - Lanes and shoulder widening, sound-wall addition, and add/restore 1-30% of total lanes and/or shoulder widening.
  - Add/restore 31-66% of total lanes + shoulder widening.
  - Add/restore 67-100% of total lanes + shoulder widening.

- Traffic Impact Intensity
  Traffic Delay - Due to temporary construction-related operations on traffic congestion (number of days).
  - Reduce widths of lanes and shoulder, closure of 1-30% of total lanes and/or shoulder or lane realignment.
  - Closure of 31-66% of total lanes + shoulder.
  - Closure of 67-100% of total lanes + shoulder.
- Environmental Impact Levels- Due to temporary construction-related operations (number of days).
  - None to Mild
  - Moderate
  - Severe

2.2.2 ABC Impact Quantification Proposal

Calculate the Bridge Construction Index for each Type, Traffic Impact, and Environmental Impact Levels.

A. Baseline Measure- Construction Time Saving
- Calculate Bridge Construction Index for conventional construction
- Calculate Bridge Construction Index for alternative ABC structure
- Calculate Earnings by ABC - capacity Improvement Acceleration
- Convert construction time (in days) into $ amount earnings.

D. Calculate Savings by ABC - Traffic Delay Reduction
- Convert traffic delay (in days) into $ amount savings.

E. Environmental Mitigation - Impact Day Savings
- Convert Environmental Mitigation (days) into $ amount savings.

2.2.3 ABC Cost Benefits Development

The following tasks are needed to develop a conversion formula to calculate cost of traffic delays:
- Conduct literature survey on public cost (traffic delay) estimates on previous projects.
- Conduct a synthesis study to gather information on assessment tools for estimating public costs (traffic delays) of a bridge project - submit research problem statement to FHWA, NCHRP, or other funding agencies.
- WSDOT ABC team will conduct partnering workshops with WSDOT and local traffic engineers to develop a tool to assess costs associated with traffic delays and early project completion.
- Coordinate with Region to provide ABC impact cost calculations and criteria.

2.2.4 ABC Selection Criteria

WSDOT ABC team will conduct partnering workshops with WSDOT Division of Engineering Services functional units, Region Design and Project Management and Project Development Team staff, and local agencies to develop an ABC selection grading system based on the above Cost Savings/Earnings benefits and Construction Costs and associated risks.

2.2.5 Schedule

- Workshop with Headquarters Traffic, Design, and Project Management on traffic impact and economic evaluation. (To be determined)
- Workshop with Region Traffic, Design, and Project Management on traffic impact and economic evaluation. (To be determined)

2.3 Industry Engagement

2.3.1 Mission

Starting in the Fall of 2008, the ABC Advisory Committee will hold workshops with fabricators, erectors, trucking, and general contractors to assess the

most effective steps that can accelerate bridge construction in moderate to high seismic zones. The workshop intends to share information on feasible construction technologies that can achieve ABC.
Discussion topics include, but not limited to, the following:

- Most feasible cast-in-place operation to accelerate construction.
- Feasible precast segment connections from a Contractor's standpoint including constructability, allowable tolerance, cost, timesaving, etc.
- Determine weight, length, geometric and other parameters associated with picking and transporting ABC prefabricated components (precast concrete, steel, etc.).
- Discuss use of new materials, including high performance concrete and steel.
- Identify current capabilities of fabricator facilities and discuss future capabilities with regard to shapes, geometry, etc. associated with prefabrication beds. Consider curvature, round vs. rectangular shapes, non-standard vs. standard shapes, tree structures (e.g. precast monolithic joint in plastic hinge zone vs. joints connecting at member interfaces), use of connectors and inserts in precast members, etc.
- Discuss most effective contractual methods to accelerate construction.

2.3.2 Schedule

- ABC Workshop with the University of Washington and Washington State University, under WSDOT research project
- February 2010 - Combine with WSDOT Structure Construction Forum held during Winter Design/Construction Conference for ABC related issues.

2.4 Technical Research

Seismic loads have been the major design consideration for bridge structures. Precast structural components pose a challenge to seismic design because the connection between components needs to have enough capacity to accommodate seismic forces and movements. The application of accelerated bridge construction requires careful attention to connection details. Only recently has the issue of connection detailing to accommodate seismic forces been addressed at the national level.

2.4.1 Current Research

WSDOT ABC team will provide technical support to or monitoring of the following research projects related to ABC:

- Precast bent cap - University of Washington
- Concrete column with steel casing connection to pier cap - UW

2.4.2 Research Statement Proposals

WSDOT ABC team has formulated the relevant topics that will serve the need in Washington State. The following is the list of research topics, which WSDOT will solicit support through NCHRP and other collaborated funding resources:

A. Investigation of column seismic connections to superstructures-

The proposal herein was to develop new connection details between precast columns and superstructures adequate to resist seismic loading.

B. Response of segmental girder systems-

More research is necessary to understand the seismic response of segmented jointed and spliced girder systems. The use of segmented superstructures has seen rapid growth in the past decade. However, more research is necessary to understand the seismic response of segmented structures. In general, a better understanding of jointed structure response is necessary – currently designed as an emulative system. Advantages of allowing joint opening in large design events can be leveraged towards energy dissipation. This leads to a redefinition of desired performance level goals. Addressing the fundamental behavioral issues of jointed systems and providing comparison to monolithic designs is warranted. Analytical and experimental testing to quantify hypotheses has been proposed. Similar work is underway currently at UCSD. Additionally, a synthesis to gather and assess the response of existing jointed and segmented bridges subjected to large earthquakes was viewed as a means of identifying further research direction in developing a solid understanding of related behavioral response. Cited areas of concern included corrosion protection, and post-event inspection procedures and tools.

C. Segmental post-tensioned columns

Segmented post-tensioned columns are currently the subjects of intense research nationally and internationally. Variations of this idea include bonded versus unbonded tendons, and mild steel crossing joints. Bonded tendons tend to provide emulative response; that is, behavior similar to conventional cast-in- place concrete columns. A major advantage of unbonded post-tensioning is the inherent self-centering feature for large displacements. Additionally, unbonded systems may provide for energy dissipation through joint opening and closing where mild reinforcement is not employed. Test results completed to date indicate segmental column performance using bonded and unbonded prestressing tendons may be equal to or better in general than conventional cast-in-place columns. Issues requiring careful investigation include tendon corrosion for unbonded systems especially where joint opening is allowed, creep monitoring, and post-event inspection. Additional research targeting these areas is considered warranted.

D. Column-to-Foundation connections-

More studies are needed to determine the performance of precast column-to-foundation connections in seismic regions.

E. Post-earthquake accelerated column repair/replacement

Benefits derived from developing ABC technologies is rapid repair of damaged structures. Rapid repair of columns is the focus of this idea, and certainly represents the quality “out-of-the-box” thinking envisioned when planning the workshop. The group discussion pointed to both temporary and

permanent applications of column repair/replacement. Existing technologies such as steel casings and carbon fiber wrapping were considered as viable options, but more research was also suggested to develop new methods and associated specifications. The ability to match existing aesthetics was considered important, and input from the construction industry considered essential.

F. Connections –Constructible, Rapid

Constructible connection details for precast elements such as bent caps, footings, and pile heads require flexibility to allow for field corrections. They also should be verifiable during construction and later while in service.

Developed details for Seismic Accelerated Bridge Construction must consider simplicity or the connection detail may not find a niche in the growing market for ABC applications. Since connections are important elements in the success of ABC in regions of moderate-to-high seismicity, a list of viable ductile connections was needed, followed by an assessment of further research needs and prioritization based on simplicity. Industry participation in this effort was deemed essential to ensure successful transition to field application. Final guidance developed must be comprehensive and include design examples where applicable.

Demonstration projects were suggested in high seismic regions to test the constructability of specific proposed connection details, with short- and long-term monitoring established to quantify service-life performance. Close collaboration with contractors and industry representatives was considered essential to meeting the goals of simple, constructible and reliable ductile connection details for SABC applications.

G. Innovative materials

A synthesis study was recommended to identify innovative material applications, tabulate material properties, and define availability. Material availability was recognized as an important element in application viability, with concerns over the high manufacturing cost of some materials such as composites. It was further recommended that the synthesis be followed by targeted research as appropriate to develop promising technologies to the point that they are readily implemented. Finally, trial applications were considered important to showcase proposed technologies. As the title of this idea suggests, research herein is continuous. Recognizing this, and understanding that innovative material applications take time to develop, the group proposed emulative response for initial applications, followed by more innovative methods as the technology matured.

H. Long-term and maintenance of ABC components in Seismic Regions

2.5 Technical Standards Development

Gathering the results from the above tasks, the WSDOT ABC team will develop the following technical documents:

A. Construction Specifications

B. Design Guide Specification
C. Standard Details-
- Precast connections at different locations, including at the point of maximum moment, within the plastic hinge zone, in the elastic region, etc.
- Standard shapes and details of bridge components including girders, columns, including segmented precast abutments.
- Optimize girder cross-sections considering new high performance materials.

2.5.1 Code recommendations for ABC components in Seismic Regions

The action plan for this topic provides a draft conclusion for every research project undertaken. The following will be developed following conclusion of each project:

- Develop connection evaluation criteria
  - Durability
  - Ability to accelerate construction
  - Ductility
  - Ability to develop full strength and strain capacity of reinforcing steel
  - Constructability
  - Reliability
  - Tolerances
  - Dependability
  - Ability to field verify performance after installation
- Evaluate current connection details published in FHWA connections catalogue.
- Develop construction specifications.
- Develop Guide Specifications for ABC and ultimately AASHTO bridge design specifications.
- Assess use of connections at different locations, including at the point of maximum moment, within the plastic hinge zone, in the elastic region, etc.
- Develop and agree upon standard shapes and details of bridge components including girders, columns, etc.
- Interact with appropriate AASHTO and Transportation Research Board committees and industry groups including the National Steel Bridge Alliance (NSBA), National Concrete Bridge Committee (NCBC), Portland Cement Association (PCA), Precast/Prestressed Concrete Institute (PCI), American Segmental Bridge Institute (ASBI), etc.
- Analytically assess the effects of seismic response by limiting or allowing joints to open in an extreme event.
- Publish Standard Seismic ABC Details.

2.5.2 Maintenance Guide Specs

- Develop inspection practices for ABC details.
- Develop non-destructive evaluation methods and tools for ABC details.
- Collect long-term performance data from field applications of ABC details.
- Assess post-earthquake performance of joints opening in jointed precast members.

- Develop methods to rapidly evaluate post-earthquake damage and replace damaged ABC components.
- Assess potential corrosion issues including inspection and replacement of unbonded tendons.

2.6 Contract Development

The WSDOT ABC team will study and develop special contract specifications that promote accelerated bridge construction. The designated work team will coordinate with WSDOT Bridge and Structures Office, HQ Construction, HQ Design, HQ Project Management, and Regions to consider the following items:

- Include constraints of construction traffic delay time in contracts.
- Consider innovation design-build contract partnership
- Consider Design Sequence contract partnership
- Early collaboration between Contractor and Designer
- Reflect Delay/Time Costs in Bid Process
- Incentive/Disincentive
- Lane rental
- Other

3. PROJECT IMPLEMENTATION PLAN

3.1 Phase I Implementation

Phase I implementation will initiate a pilot demonstration program in the short term (2009 - 2010). Phase I will implement the ABC decision criteria in the Type Selection process and will target established current WSDOT technologies to accelerate bridge construction. Technologies such as precast girders and segmental precast abutments are currently viable solutions to accelerate bridge construction.

A. Promote bridge construction impacts measure concept to the Regions

- Present bridge construction impacts approach in a Branch Chief workshop.
- Conduct bridge construction impacts workshop for technical and project seniors.
- Conduct information meeting for Structure Construction and Structure
- Office Engineer on the bridge construction impacts procedures to support Structure Design PE's.
- Hold informational meeting/workshops with Region Traffic, Design and Project Management on bridge construction impacts process.

B. Initiate ABC Selection Evaluation in Type Selection phase starting 2009 - Applies to individual bridges (Replacement or Widening)

- Initiate Bridge Construction Impact (BCI) evaluation
- Provide Baseline Measure to bridge construction impacts and project costs.
- Provide ABC alternatives and ABC Measure to bridge construction impacts and benefits (cost savings and earnings). Determine costs of project delays.
- Coordinate with the Regions to provide ABC impact cost calculations and criteria.
- Use currently available and approved ABC technology alternatives use "Lessons Learned" Report for selection guide.

C. The ABC Advisory Committee will manage the pilot program and provide support during the planning, design, and construction phases of the selected projects.
D. The ABC Advisory Committee will document "lessons learned" from the Phase I implementation and develop improvements on future ABC development and implementation.

3.2 After Action Review

3.2.1 Lessons Learned

- Collect design and details challenges and obstacles
- Collect specifications and contracting challenges
- Collect construction difficulties- are there any suggested alternatives from Contractor?
- Share accelerated construction practices from other national and international agencies.
- Publish case studies.

3.2.2 Recommendation

- Develop recommendations from lessons learned for improvement
- Share accelerated construction practices from other national and international agencies.
- Publish case studies.
- Provide audit evaluation to determine continuing and increased use of the pilot program.
- Provide periodic audit and evaluation report to the ABC Executive Committee and State Bridge Engineer for further continuation of the pilot program.

When selected new structural details, technologies and developments mentioned in the above have been established, they will be included in Phase II demonstration projects to test the implementation feasibility. It is expected that the success of Phase I and II implementation will lead to widespread use of ABC in Washington State. The long-term goal is to implement ABC as the standard bridge project delivery for WSDOT and Washington State.

4.0 Decision-Making Matrix

The decision-making matrix checklist should be accompanied with all bridge preliminary plans. This matrix allows identifying ABC candidates at early stage of bridge design. the same process could be used at the project development stage for some expedited projects. Typical questions for decision-making matrix are shown in the following table:

4.1 ABC Decision Making Checklist

	Question	Yes	Maybe	No
1	High traffic volume			
2	Emergency replacement			
3	Worker safety concerns			
4	High daily traffic control costs			
5	Evacuation route or over railroad or navigable channel			
6	Lane closures or			
7	detours			
8	Critical path of project			
9	Close during off-peak traffic			
10	Rapid recovery/repair required			
11	Adverse economic impact			
12	Weather constraints			
13	Environmentally sensitive site			
14	Natural or endangered species			
15	Feasibility if historic bridge			
16	Multiple similar spans (segments)			
17	Problem for ready-mix concrete			
18	Delay-related user cost concern			
19	Innovative contracting strategies			
20	Group with other bridges			
21	Future use			
	Totals			